Section 9 Pollen Analysis

9.1 Introduction

Results of pollen analysis were prepared in a report on *Pollen Analysis of Samples From the Honolulu High-Capacity Transit Corridor Project, Honolulu, Hawai‘i* by Linda Scott Cummings presented in full in Appendix F. An overview of prior palynological studies in the vicinity is presented here, followed by a summary of the pollen results from the City Center Section study area.

9.2 Overview of Prior Pollen Studies in the Vicinity

Relatively few pollen studies have been carried out near the HHCTCP City Center segment. Previous pollen studies in the Fort Shafter Flats area (Wickler et al. 1991), Kūwili and Kawa fishponds Fishpond area (Athens and Ward 1997, McGerty et al. 1997, McDermott and Mann 2001, Hammatt et al. 2008), and the Kekaulike area of Downtown Honolulu (Athens and Ward 1994) are summarized below.

A statement of caution is needed as pollen studies by their nature are detailed and nuanced. Only a broad-brush overview is attempted here, and the reader is referred to the studies themselves for details. The geographic relationship of prior pollen studies discussed to the present pollen sample areas is presented in a contemporary aerial photograph (Figure 80)

Wickler et al. 1991 (Fort Shafter Flats Paleoenvironmental and Archaeological Investigations)

The International Archaeological Research Institute, Inc. (IARII) carried out palynological studies in association with a Fort Shafter Flats sewer line project. Seven pollen samples were taken from a Profile 1 area and six from a Profile 10 area. At least 84 species or types, belonging to 49 families, are represented (Wickler et al. 1991:37). Curiously, given this diversity, only one Polynesian introduced species was documented (*Aleurites moluccana*, *kukui*). The study concludes:

> …one conclusion is firm: the picture of a lowland *Pritchardia* (*loulu*) forest with a high diversity of dryland to mesic forest types offers a new level of understanding of the pre-contact natural lowland vegetation, very different from the vegetation seen today or even during the period represented by Pollen Zone A around AD 768-997. (Wickler et al. 1991:51)

In the oldest Pollen Zones *Pritchardia* remains quite constant, accounting for 27% to 28% of the pollen, but by the AD 768-997 sample, it drops to 2%.

Athens and Ward 1994 (Kekaulike Data Recovery)

In association with archaeological data recovery work by Archaeological Consultants of Hawaii (Riley et al. 1995) at a Kekaulike revitalization project (bounded by Hotel, Kekaulike, King and River Streets), IARII (Athens and Ward 1994) carried out paleoenvironmental investigations ,including the processing of 12 pollen samples and 3 radiocarbon dates from a

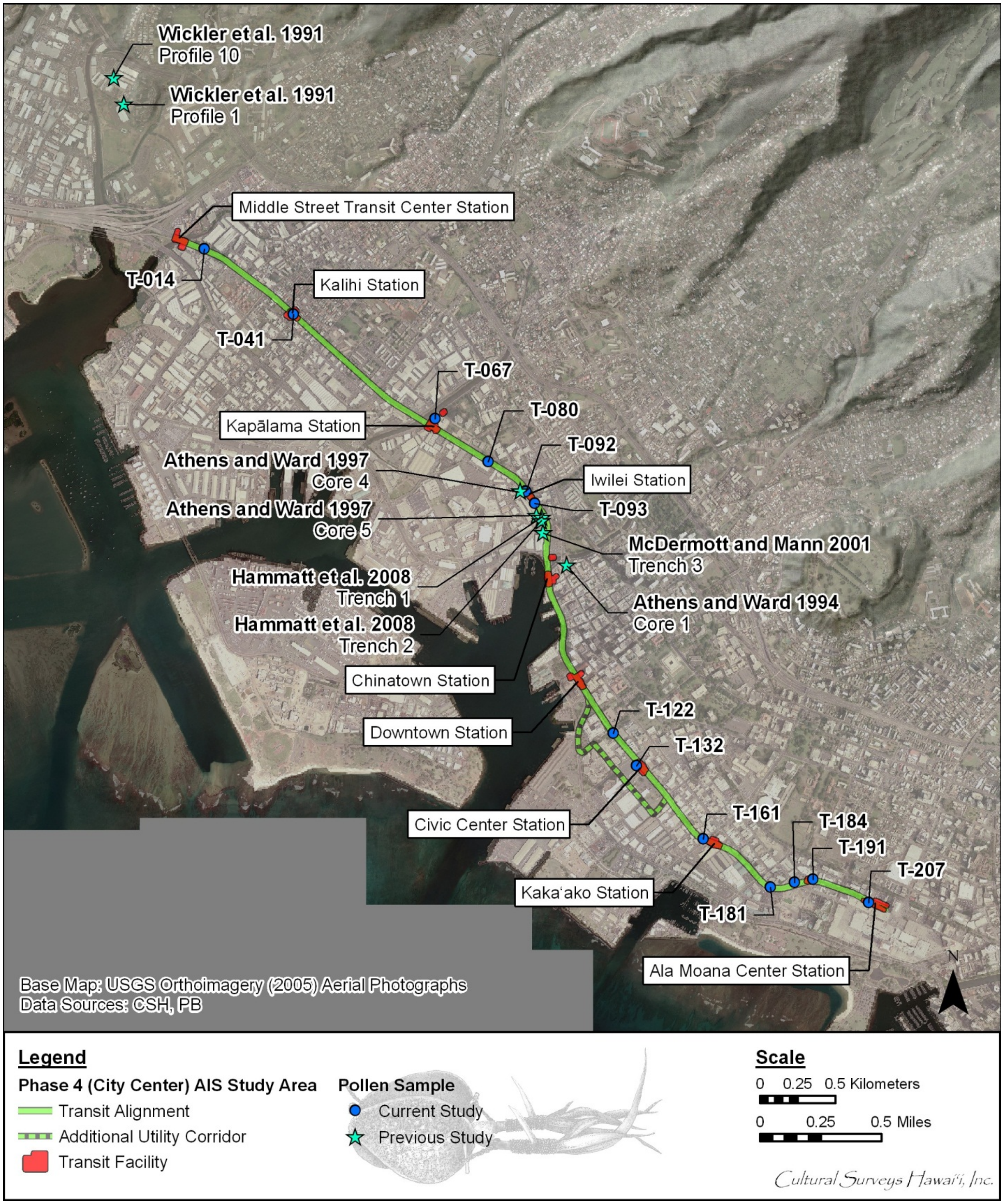

Figure 80. Aerial photograph showing relationship of prior pollen study areas to the present pollen sampling locations

single core. The dates collected were all well before human arrival (the most recent is reported as 2330+-60 B.P.), and thus all pollen results appear to relate to a pristine Hawaiian environment.

The authors conclude:

> Pollen results indicate an open lowland forest community dominated by Pritchardia palms with a diverse array of other dry-mesic forest species present in small numbers. The Kekaulike pollen record is essentially identical to those documented at Ft. Shafter flats and a Pearl Harbor sampling location for the Holocene period prior to human settlement. It is apparent that unlike the windward side of O‘ahu, leeward lowland vegetation communities had no co-dominant species such as Dodonaea and Kanaloa as documented in cores from Kawai Nui Marsh and Hamakua Marsh near Kailua. (Athens and Ward 1994:iii)

Athens and Ward 1997 (Kūwili Fishpond Paleoenvironmental Study)

In 1997, Athens and Ward (1997:46) conducted subsurface coring, radiocarbon dating, and paleo-environmental investigation at Kūwili Fishpond in order to "…assess the possible presence of a fishpond layer, to date it, and to establish the environmental context of its construction..." and to "…obtain a paleo-environmental record of the Holocene, including, if possible, information concerning prehistoric Hawaiian settlement and land use…" Five core samples were extracted and two of these were analyzed: Core 4 (which reached a depth of 2.59 meters) was taken to determine the environment around Kūwili Fishpond; Core 5 (which reached a depth of 27.7 meters) provided a paleo-environmental record for the period from 9000 B.P. to 2000 B.P.

An unconformity was identified in Core 5, which indicated a sedimentary gap between 2000 B.P. and about 450 to 350 B.P. (Athens and Ward 1997:iii). This unconformity was present in other samples taken near the project area: at Kekaulike (Athens and Ward 1994), Fort Shafter Flats (Wickler et al. 1991), and Weli Fishpond (Athens and Ward 1996).

Based on the results of pollen analysis of sediment samples and the two radiocarbon dates, Athens and Ward (1997) concluded that fishpond construction occurred rather late in the prehistoric Hawaiian period, after upland forests had been affected by inland expansion of Hawaiian land use:

Kanaloa kahoolawensis had already disappeared from the record, and *Pritchardia* was represented by only trace quantities of pollen compared to 15 to 20 percent or more during the pre-Polynesian period. This evidence alone suggests a post-AD 1500 time period for construction of the [Kūwili] fishpond." (Athens and Ward 1997:47)

McDermott and Mann 2001 (Nimitz Hwy. Water System Archaeological Inventory Survey)

Cultural Surveys Hawai‘i (McDermott and Mann 2001) carried out an archaeological inventory survey in support of a Nimitz Highway Water System Improvements project, focused primarily on the prior location of Kawa Fishpond (SIHP #50-80-14-5966) in Iwilei. Three samples (from Strata XII, XIII, and XIV of Test Trench 3) were submitted for pollen analysis (carried out by Dr. Jerome Ward). The results are briefly summarized in the following table.

Table 268. Summary of pollen results recovered from Kawa Fishpond (McDermott and Mann 2001)

Strata	Estimated date*	Pollen Results
XII (175-205 cmbs)	AD 1450-1650	Polynesian introductions *Aleurites moluccana* and *Cordyline fruticosa* were identified. Native pollen taxa identified included: Cheno-am type, *Pritchardia*, and *Ilex*. A low level of Cyperaceae (sedges) and a moderate level of fire use in the catchment were indicated.
XIII (205-230 cmbs)	AD 1150-1290	Polynesian introductions *Aleurites moluccana, Cordyline fruticosa* and *Cocos nucifera* were identified as well as *Acacia koa*, cheno-am type, *Pritchardia*, and a diversity of traces of Dry-Mesic and Mesic wet forest types (*Dodonaea viscosa, Erythrina sandwicensis, Kanaloa kahoolawensis, Pandanus tectorus, Sida sp., Waltheria indica, Freycinetia arborea, Tetraplasandra gymnocarpa*). A high level of Cyperaceae (sedge) pollen and a moderate level of fire use in the catchment were indicated.
XIV (230-240 cmbs)	AD 711-1029	Polynesian introductions *Aleurites moluccana*, and *Cocos nucifera* were identified as well as *Acacia koa*, cheno-am type, *Pritchardia*, and a diversity of Dry-Mesic and Mesic wet forest types (*Sida*, *Tetraplasandra gymnocarpa*. A high level of Cyperaceae (sedge) pollen and a moderate level of fire use in the catchment were indicated.

*consideration of the marine reservoir effect was a factor in the calibration of carbon dates

Dr. Ward concluded:

> The three samples from… [the Nimitz Highway Water System project] appear to represent strata deposited during a period of Hawaiian occupation before large scale forest destruction took place. This conclusion is based on the fact that a diversity of pollen types was recovered from the dry, mesic, and wet forest types, especially noted in the lower two samples suggesting the presence of pristine Hawaiian forest. No evidence of recent disturbance or historic layers was seen in this profile. [McDermott and Mann 2001:Appendix B]

The authors note the complete absence of introduced species (such as pollen from *Leucaena* and *Prosopis*) and suggest the possibility that these sediments were somehow “capped” prior to the abundance of historically introduced species (McDermott and Mann 2001:60).

Hammatt, Hazlett and Shideler 2008 (Kūwili Fishpond)

Previous analysis of pollen samples from Kūwili Fishpond (McGerty et al. 1997) indicated the project area had become a marsh by about 2000 B.P, with a concomitant surge in sedge and grass pollen and the disappearance of many of the forest pollen types seen in older samples.

Unfortunately, there is a gap in the sediment sequence from approximately 2000 B.P. to 400-350 B.P. due to an unconformity. This unconformity is present in other samples taken near the project area: at Kekaulike (Athens and Ward 1994), Fort Shafter Flats (Wickler et al. 1991), and Weli Fishpond (Athens and Ward 1996).

A research objective for the project was to obtain a record of the environment throughout the Holocene, not only after the initial construction of the fishpond, but also before construction, when the area was part of a high energy marine embayment and/or lagoon. This record might extend to a period before Hawaiian occupation of the islands, and might provide information on the time and extent of the impact of the inland expansion of Hawaiian settlement and agriculture on lowland vegetation and upland forests.

Pollen analysis of samples from Trenches 1 and 2 indicated that the area selected for the fishpond exhibited many similarities between Stratum IV (prior to the construction of the fishpond) and Stratum III (after the construction of the fishpond). A variety of pollens were found in both Stratum IV and Stratum III. Cyperaceae (sedge) pollen dominated the pollen record in both Strata, indicating that the area supported a large population of sedges. Cheno-am pollen (probably from *Chenopodium oahuense*, a shrub that favors dry habitats including dry coastal areas) was present in Stratum IV and in lesser quantities in the lower portion of Stratum III. Poaceae (grass) pollen suggests grasses shared the margins of the wetland and later the fishpond with the sedges. *Pritchardia* (*loulu* palm) pollen indicates these trees were present in the coastal area in both the pre- and post-construction periods. Small quantities of Araliaceae and Anacardiaceae indicate that shrubs or trees of these families grew nearby in both periods as well. Myrsine and Myrtaceae pollens (both frequently wind-transported) also were found in both strata. Euphorbia (introduced to Hawaiʻi by the Polynesian settlers) grew in the vicinity of the fishpond

Pollen found only in Stratum III (during the life of the fishpond) included a variety of endemic or indigenous as well as Polynesian- and European-introduced trees, shrubs, and plants. The pollen record includes flora from a mix of environments; dry coastal areas (*Aleurites*, *Cordia*, *Sida*, *Plumbago*, *Solanum*, *Cocculus*, *Euphorbia*, *Pandanus*, and *Prosopsis*) bogs and mudflats (*Ilex*, *Nema Sandwicensis*, and *Cressa*), and dry to mesic (moderately moist) forests (*Hediotus*, *Zanthoxylum*, *Cordia*, *Plumbago*, *Aleurites*, *Sida*, and *Solanum*). This pollen record suggests the development of a new mixture of dry forest and coastal scrub in the vicinity of the fishpond.

Microscopic charcoal particles in the soil samples indicate that both the Stratum IV and Stratum III layers postdate the arrival of Polynesian settlers; the charcoal data reflects local land clearing activity both prior to and after construction of Kūwili Fishpond but yields little data on the time and extent of the inland expansion of Hawaiian settlement and agriculture.

Unfortunately, the samples collected during the project do not appear to provide much information about the effect of Hawaiian settlement, agriculture, or inland expansion upon the local vegetation or upon the inland forest. According to McGerty et al. (1997) the area had become a marsh by 2000 B.P.; the earliest samples from the current project indicate that the area had remained marshland for the next thousand years, and the same flora (*Pritchardia*, Cyperaceae and Poaceae) that had dominated the vicinity before establishment of the fishpond continued to grow in the area afterward. The pollen record does indicate a change in flora including several Polynesian-introduced plants (*Aleurites*, *Cordia*, and *Ipomea batatas*) in the upper (stratum III) layers but certainly not the "… sudden and spectacular decline in the native forest community…" reported by Athens and Ward (1997:45). The pollen record shows little evidence of Hawaiian settlement or agricultural activity in the project area other than the establishment of the fishpond.

9.3 Pollen Results from the Present Study

Pollen results from the City Center AIS are presented in a pollen analysis report prepared by Linda Scott Cummings with assistance from R. A. Varney, PaleoResarch Institute, Golden, Colorado are presented at the end of this Section. Finds by test excavation are summarized in the following Table 269. Pollen taxa identified are summarized in the following Table 270, with graphs of pollen abundance included at the end of the following Cummings and Varney (2013) report.

9.3.1 Cultigens

Identified Polynesian cultigens included *Cocos nucifera* (*niu* or coconut) in T-014, T-080, T-122, T-181, T-184), *Cordyline* sp. (*kī* or ti in T-093), and *Colocasia* sp. (taro or *kalo* in T-041, T-080 and T-093).

There was only one grain of *Saccharum* sp. (sugarcane, *kō*) identified in T-067, near the Kapālama Drainage Canal, but it is unclear whether this represents traditional Hawaiian cultivation or later commercial cultivation.

Morinda pollen (*noni*) was noted in T-093 and is indicated in Cummings and Varney (2013), Figure 2 as also present in T-067.

It appears from Cummings and Varney (2013) Figure 1 that a very small quantity of *Artocarpus* (breadfruit or *‘ulu*) was identified from T-207.

The Cummings and Varney (2013:13) report notes that in two of the three instances of the documentation of taro pollen there are also indications that this represents post-Contact taro cultivation. In the case of T-041, the *Colocasia* pollen was accompanied by *Leucaena* (*koa-haole*), *Prosopis* (*kiawe*), and *Oryza*-type pollen In the case of the T-080 taro pollen the presence of *Commelina* and *Oryza*-type pollen indicated post-Contact cultivation. Only in T-092 was there no alien pollen observed with the taro pollen, suggesting pre-Contact taro-cultivation.

The seeming complete absence of *kukui* (*Aleurites moluccana*) from the pollen record in the Cummings and Varney (2013) report is likely attributed to the fact that *kukui* is insect-pollinated. Insect-pollinated plants are not prolific pollen producers and their pollen is less widely represented in the pollen record.

With the exception of coconut palms (presence suggested in the pollen from five test excavations), the pollen record suggests a notable lack of traditional Hawaiian agriculture. This is understood to at least in part reflect the generally low rainfall of the City Center corridor (the

Table 269. Summary of Pollen Samples

Provenience	**Comments**
T-014, Kamehameha Highway, Stratum II, 1.80-2.07 mbs	*Leucaena* and *Prosopis* pollen indicate historic sediments (or contamination from historic sediments). Sample was dominated by Poaceae pollen most consistent with *Oryza*. Cheno-am pollen suggests *‘aheahea* growth on drier sediments. *Cyperaceae* pollen suggests neighboring growth of sedges. local growth of *niu*, *kōlea*, trees in the myrtle family, *‘ilima*, ,members of the sunflower family including the chicory tribe, plants of the mustard family and *kanawao*; microscopic charcoal and charred stems of plants of the sunflower family suggests burning of rice fields. Growth of ferns in the vicinity is indicated. The presence of foraminifera suggests marine water intrusion.
T-041, Dillingham Boulevard, Stratum II, 0.46-0.64 mbs	*Leucaena* and *Prosopis* pollen indicate historic sediments (or contamination from historic sediments). This sample was dominated by Cheno-am pollen, suggesting a sizeable population of *Chenopodium oahuense (‘aheahea*) growing in the area and suggests a relatively dry habitat. It appears that *kukaemoa*, *kanawao*, *‘ilima*, various members of the sunflower family, sedges, spurge, grasses, and *mohihihi* or beach pea grew in the area. This sample also contained both *Oryza* and *Colocasia* pollen, indicating rice and taro agriculture. The minor signature for other plants that usually populate wet areas, such as sedges suggests the possibility that specific fields were located in this area that were tended and weeded. *‘Aheahea* may have grown in drier sediments outside the ponds. Microscopic charcoal and charred Poaceae (grass) leaf fragments suggest the possibility that local fields were burned.
T-067, Honolulu Community College, Stratum II (SIHP #-7426), 1.52-1.54 mbs, 1.57-1.60 mbs, and 1.67-1.69 mbs	The pollen record is very different from that noted in Trench 41. In this location Cyperaceae pollen was dominant, indicating a well-established wetland that supported a large sedge population. *Vigna* pollen (cf. *Vigna sinensis*, cow pea, or “yard-long beans”) from this location suggests use of this area for growing these introduced beans used in Chinese cooking. *Oryza*-type pollen suggests rice fields were located in the wetlands along Kapālama Stream. *Typha angustifolia*-type pollen indicates nonagricultural wetland vegetation including cattails. A single *Saccharum* pollen grain indicates the presence of a sugarcane field within close proximity to the stream, as well. Charred Poaceae (grass) fragments suggest burning of rice fields or perhaps nearby sugarcane fields. High pollen concentrations are consistent with wetlands, whether they represent a marsh or agricultural fields.

Provenience	Comments
T-080, Dillingham Boulevard, Stratum II, (SIHP #-7426), 1.40-1.43 mbs, 1.63-1.67 mbs, and 1.85-1.88 mbs	*Prosopis* pollen indicates historic sediments (or contamination from historic sediments) for the upper two samples. Cyperaceae pollen is supporting evidence for the presence of wetlands. Cheno-am pollen probably represents *Chenopodium oahuense (ʻaheahea*), a shrub that would have grown in drier setting outside the wetland. Large size Poaceae pollen was observed in the upper two samples, suggesting the possibility that either sugarcane was grown in the area or that *pili* grass grew locally. *Typha* pollen suggests Cattails. The presence of coconut trees growing in this general area is indicated. Exotic *Commelina* (*Honohono)* pollen suggests disturbed areas and a possible date of mid to late nineteenth century (or later) for the middle sample from this trench. *Colocasia*, representing taro cultivation was observed in the upper sample from this trench.
T-092, Kaʻaʻahi Street, Stratum II, SIHP #-5368, 1.73-1.83 mbs	The pollen record was dominated by Cyperaceae indicating a large population of sedges, perhaps around the edges of Kūwili fishpond. *Oryza* pollen suggests use of this fishpond for growing rice. Growth of *kauila*, *kōlea*, a member of the myrtle family, *pāpala*, probably *ʻaheahea*, *ʻaʻaliʻi*, *ʻawiwi*, *ʻilima*, *ʻuhaloa*, various members of the sunflower and mustard families and the aliens sorrel and *kiawe* were indicated.
T-093, Kaaahi Street, Stratum IIa, SIHP #-5368, 1.82-2.29 mbs; Stratum IIb, SIHP #-5368, 2.50-2.74 mbs	The lower sample IIb sample was dominated by Cyperaceae pollen indicating an abundance of sedges. An increase of a variety of other pollen types in the upper sample indicates the possibility that the water was more open. *Oryza* indicating rice cultivation was present in both samples. Taro was indicated by a single *Colocasia*-type pollen grain. The lower sample indicated the growth of a local member of the sumac family such as mango, *hame*, *ʻahakea, kī*, *kōlea*, a member of the myrtle family, *kukaemoa*, *loulu*, a member of the buckthorn family, probably *ʻaheahea*, *ʻaʻaliʻi*, *ʻilima*, various members of the sunflower and mustard families, and *kaliko*. The upper sample also indicated *loulu*, probably *ʻaheahea*, sedges, and rice. As well as acacia, *noni*, *aʻe*, *au*, wild buckwheat and Australian pine.
T-122, Halekauwila Street, Stratum II, SIHP #-2963, 1.65-1.70 mbs	*Cocos nucifera* and *Prosopis* pollen were co-dominants representing coconut or *niu* and historically introduced *kiawe*. The exotics *Casuarina* and *Leucaena* also were present. Sedges are indicated by Cyperaceae pollen and *Oryza* pollen indicates rice cultivation. Local growth of *hame*, *kōlea*, a member of the myrtle family, *loulu*, probably *ʻaheahea*, *ʻaʻaliʻi*, a member of the nightshade family, members of the sunflower and mustard families, *Cressa*, *kokolau*, and *nohunohu* is indicated. Microscopic charcoal suggests burning of the land.

Provenience	**Comments**
T-132, Halekauwila Street, Stratum II, 1.37-1.39 mbs, 1.42-1.44 mbs, and 1.47-1.49 mbs	All three of these samples contained *Prosopis* pollen, representing the alien *kiawe*. In addition, a small quantity of *Leucaena* pollen was noted, representing *koa haole*. Due to the sandy nature of these samples it is possible there was downward intrusion of pollen from more recent vegetation above. The three samples examined from this location were dominated by Poaceae pollen, with much smaller quantities of Cyperaceae pollen, indicating a local habitat dominated by grasses and also including sedges. *Acacia* pollen was observed in small quantities in the upper and lower sample from this trench, documenting local growth of *koa*. Recovery of a small quantity of *Cocos nucifera* pollen in the upper sample represents local growth of coconut trees in the area at the time these sediments accumulated. No evidence of agriculture was noted in any of these samples. Small quantities of foraminifera and a polychaete worm jaw fragment were noted in this sample, which are consistent with inundation of these sediments with marine water.
T-161, Ross Dress-for-Less at Ward Avenue, Stratum IIa, 1.30-1.35 mbs, 1.35-1.40 mbs, and 1.40-1.45 mbs	The pollen record is dominated by Cyperaceae pollen in all three of the samples examined, suggesting the presence of a sedge marsh in this area. Very small quantities of Poaceae pollen that exhibited the characteristics typical of *Oryza* (rice) were observed in each of these three samples. It is possible that rice was grown in this area, but that use of these wetlands for rice fields did not persist over time. The uppermost sample yielded a diminished quantity of Cyperaceae pollen, offset by a large increase in *Myrsine* pollen, reflecting *kōlea* trees growing in or at the edges of the wetlands. This pattern is probably associated with a change in the marsh, such as more open water and a smaller sedge population. This also might reflect clearing some of the sedges and use of the wetland for another purpose, such as a taro field but no *Colocasia* pollen was observed in this sample to substantiate such a use.
T-181, Queen Street, Stratum II, SIHP #-6856, 1.20-1.30 mbs	Several alien species were indicates including *Casuarina*, *Leucaena*, and *Prosopis* pollen. The pollen record was dominated by Myrsine pollen suggesting open water and wind transport of pollen from *kōlea* trees growing nearby. Local vegetation appears to have included *niu*, *ʻaiea*, *loulu*, and probably *ʻaheahea*.
T-184, Waimanu Street, Stratum II, SIHP #-6856, 1.39-1.47 mbs	The pollen record is dominated by *Cyperaceae* pollen suggesting the growth of sedges in this area. *Prosopis* (*kiawe*) pollen was noted. The presence of a member of the sumac family such as mango, *niu*, *kōlea*, probably *ʻaheahea, ʻilima, hinahina*, *kokolau,* are indicated. The large quantity of charcoal suggests burning of agricultural stubble or weeds.

Provenience	**Comments**
T-191, Kona Street West of Ala Moana, Stratum IIa, 0.85-0.90 mbs and 1.05-1.10 mbs; Stratum IIb, 1.20-1.25 mbs	The pollen record from this trench was heavily dominated by Cyperaceae pollen, representing a local population of sedges growing in a marsh. Cheno-am pollen indicates that *‘aheahea* likely grew in drier sediments somewhat removed from the marsh. Acacia pollen was observed in the uppermost sample, indicating that *koa* grew in the area. Recovery of very small quantities of a variety of other pollen taxa from these sediments is typical of the pattern observed in other samples and represents general pollen rain probably derived from wind transport. Very small quantities of *Prosopis* pollen were observed in each of these samples. It is likely that these represent intrusion of relatively modern pollen, either through rare downward movement through the sediments or perhaps introduced at the time of sample collection. The pattern observed in these samples does not suggest severe contamination of the pollen record by modern or recent pollen. No evidence of agricultural activity was noted in samples from this trench. Foraminifera were much more common in these samples suggesting more regular marine inundation of these sediments. Total pollen concentration was moderately high, which is typical of marshes.
T-207, Kona Street at Ala Moana Center, Stratum IIa, SIHP #-6636, 0.91-0.95 mbs, 1.07-1.11 mbs, and 1.27-1.31 mbs	The pollen record again was dominated by Cyperaceae pollen, Increasing quantities of Poaceae and Cheno-am pollen, accompany by declining quantities of Cyperaceae pollen indicate that these sediments dried out through time, but still were sufficiently wet to support a sedge marsh for the entire time period represented. *Acacia* pollen was observed in the upper two samples from this trench, indicating local growth of *koa*. There was evidence of fire in the middle sample. Once again, very small quantities of *Prosopis* pollen were noted in each of these samples, but the quantity does not appear to be sufficient to indicate a problem with the record as a whole.

Table 270. Pollen Taxa Identified in the City Center Section

Scientific Name	**Common Name**	**Nat**[1]	**Pol**	**End**	**Ind**
Trees:					
Acacia	*Koa, kolu, koai‘e*	x		x	
Alectryon	*Mahoe, ‘ala‘alahua*			x	
Anacardiaceae	Mango family	x		x	
Antidesma	*Hame, ha‘a, ha‘amaile, hamehame, mehame, mehamehame, bignay*			x	
Artocarpus	Breadfruit, *‘ulu*		x		
Cheirodendron	*‘Olapa, lapalapa*			x	
Cocos nucifera	*Coconut, niu, alolani*		x		
Morinda trimera	*Noni kauhiwi*			x	
Myrsine	*Kōlea, ōliko, kōlea lau nui, kōlea lau li‘i*			x	
Myrtaceae	Myrtle family	x	x	x	x
Nothocestrum	*‘Aiea, halena*			x	
Pandanus tectorus	*Hala, pū hala*				x
Pelea clusifolia	*Kukaemoa, kolokolo mokihana*			x	
Pisonia	*Pāpala kēpau, pāpala*			x	x
Pittosporum	*Hō‘awa, ha‘awa*	x		x	
Pritchardia	*Loulu* palm, *Loulu hiwa*			x	
Rhamnaceae	Buckthorn family	x		x	x
Straussia	*Kōpiko kea*				x
Zanthoxylum	*A‘e, manele, hea‘e, kawa‘u, kawa‘u kua kuku kapa,* prickly ash			x	
Shrubs:					
Broussaisia arguta	*Kanawao, pū‘ahanui*			x	

[1] Nat = Naturalized; Pol = Polynesian-Introduction; End = Endemic; Ind = Indigenous

Scientific Name	Common Name	Nat[1]	Pol	End	Ind
Chenopodium	Goosefoot, pigweed, lamb's quarters, Mexican tea, worm seed, *‘āheahea*, *‘ahea*, *‘ahewahewa*, *alaweo*, *alaweo huna*, *‘aweoweo*, *kaha‘iha‘i*	x		x	
Cheno-am	Achyranthes, *Chenopodium oahuense*, *Amaranthus*, *Charpentiera*, etc.	x		x	
Cressa	Cressa				x
Euphorbia (shrub or herb)	*Kaliko*, spurge, Mexican fireplant (wild poinsettia)	x		x	
Fabaceae	Legume of pea family	x	x	x	x
Senna gaudichaudii	*Kolomona*, *heuhiuhi*, *kalamona*, *uhiuhi*	x			x
Hibiscus	*Aloalo*, *hau*, *koki‘o*, *ke‘oke‘o*, *(hau hele*, *koki‘o kea*, *pamakani)*, *ma‘o hau hele*, *kaiohala (akiahala*, *hau hele wai)*, *koki‘o (mākū),* large leaved *hau*, cotton or confederate rose (*aloalo waikāhuli, waikāhuli*)	x		x	x
Kadua	*Au*, *pilo*, *‘Awiwi*, *kio‘ele*, etc.	x		x	
Labordia	*Kamakahala*			x	
Malva	Mallow	x			
Plumbago	*Ilie‘e*, *hilie‘e*				x
Scaevola	*Naupaka*			x	x
Sida	*‘ilima*, Prickly *Sida*	x			x
Solanaceae	Nightshade family	x	x?	x	x
Vitex	*Kolokolo kahakai*, *hinahina kolo, mānawanawa, māwanawana, pōhinahina, pōlinalina*, beach vitex				x
Waltheria	*‘Uhaloa* (*‘ala‘ala pū loa*)				x?
Herbs:					
Low-spine	Sunflower family; includes	x		x	x

Scientific Name	Common Name	Nat[1]	Pol	End	Ind
Asteraceae	ragweed and others				
High-spine Asteraceae	Sunflower family; includes *Bidens*	x		x	x
Liguliflorae	Sunflower family, chicory tribe	x			
Boerhavia	*Alena, anena, nena*	x			x
Bonamia menziesii (Perispermum)	None (Vine in dry to mesic forest)			x	
Brassicaceae	Mustard family				
Lepidium	*‘Anaunau, ‘anounou, ku nana*	x		x	x
Cleome	Spider plant, spider flower, spider wisp, *honohina, ‘ili‘ohu, honohino*	x			x?
Commelina	*Honohono*	x			
Cressa truxillensis	Cressa				x
Plantago	*Laukahi kauhiwi*, plantain	x		x	
Polygonum sp.	Knotweed/smartweed	x			
Polygonum glabrum	*Kāmole*	x?			
Sicyos	*‘Anunu*			x	
Stenogyne	*Pua‘ainaka, Ma‘ohi‘ohi, Mohini*			x	
Tribulus	*Nohu, nohunohu*, goat head	x			x
Grasses, etc.:					
Cyperaceae	Sedge family	x		x	x
Poaceae	Grass family	x		x	x
Typha	Cattail	x			
Cultigens:					
Colocasia	Taro, *kalo*		x		
Gossypium tomentosum	*Ma‘o, huluhulu*, native cotton			x	
Oryza	Rice	x			
Saccharum	Sugarcane, *kō*	x	x		
Vigna	*Mohihihi, nanea*, beach pea			x	x

Scientific Name	Common Name	Nat[1]	Pol	End	Ind
Aliens:					
Leucaena	*Koa-haole (ʻekoa, lilikoa*)	x			
Prosopis	*Kiawe*, mesquite	x			
Indeterminate	Too badly deteriorated to identify				
Spores:					
Dicksoniaceae	Tree fern family			x	x
Lycopodium cernuum	Club moss (*Wiwaeʻiole*)			x	
Monolete	Fern				
Trilete	Fern				
Other:					
Tetraploa					
Starch angular	Grass seed-type starch				
Foraminifera	Forams				
Spirogyra	Algae				
Scolecodont	Polychaet worm jaw				
Microscopic charcoal	Microscopic charcoal				
Charred Asteraceae fragments	Charred pieces of a member of the sunflower family				
Charred Poaceae fragments	Charred pieces of grass				

Plant names and information derived from (Wagner et al. 1990); Fern (spore) names derived from (Selling 1946)

Pollen identifications to species were made based on the fact that only one species is reported by (Wagner et al. 1990). Species identification was not made based on morphologic characteristics observed under the microscope.

Aloha Tower rain gauge for example averages 9.3 inches annual rainfall rain gauge (Source: Pacific Disaster Center). The other explanation for the lack of traditional Hawaiian cultigens in the samples is that several of these plants are insect-pollinated (taro, *kukui*, and noni). Unlike wind-pollined plants (i.e. grasses, rice, Cheno-Ams, pine, oak) which produce an abundance of pollen that often travels long distances and survives well in the archaeological record, insect-pollinators produce less copious amounts of pollen and are, therefore, usually under-represented in the archaeological record.

The only post-Contact cultigens identified in the pollen record were rice (discussed further below) and *Vigna* pollen (cf. *Vigna sinensis*, cow pea, or “yard-long beans”) from T-067 located at Honolulu Community College suggesting use of this area for growing these introduced beans used in Chinese cooking.

9.3.2 *Oryza*-type Pollen and the Evidence for Rice Cultivation

The identification of *Oryza*-type pollen in eight of the test excavations (T-014, T-041, T-067, T-092, T-093, T-122, T-161 and 184) and the presence of microscopic charcoal and charred stems of plants of the sunflower family suggesting burning of rice fields suggests that rice cultivation may have been extensive in the vicinity. Coulter and Chun (1937:21) documents that in 1892 there were many hundreds of acres under rice cultivation in Kalihi, “Kewalo and vicinity:, Pālama and Waikīkī (Table 270). Coulter (1937:20) cites Damon in an article in *The Friend* in 1882 as relating that “on Oahu ... Every available inch of ground seemed to be utilized” It would be no surprise that the burning of dried rice paddies after harvest would not lead to the broadcasting of rice pollen on the trade winds.

Table 271. Rice Farming Districts on O‘ahu, 1892 (Acres) (from Coulter 1937:21)

Rice Farming Districts on Oahu, 1892

	Acres		Acres
Aiea and Kalauao	76	Mokuleia and vicinity	738
Halawa	117	Palama	200
Hauula	25	Palolo	102
Heeia and Kaneohe	200	Punaluu and vicinity	300
Honouliuli, etc.	147	Waialae	32
Kaalaea and Kahaluu	300	Waialua	180
Kahuku	50	Waiau, Manana and Waiawa	262
Kailua and Waimanalo	400	Waikane and vicinity	200
Kalihi and Moanalua	150	Waikele and Waipio	333
Kewalo and vicinity	75	Waikiki	542
Laie	45	Waimalu	135
		Other places	50
			4,659

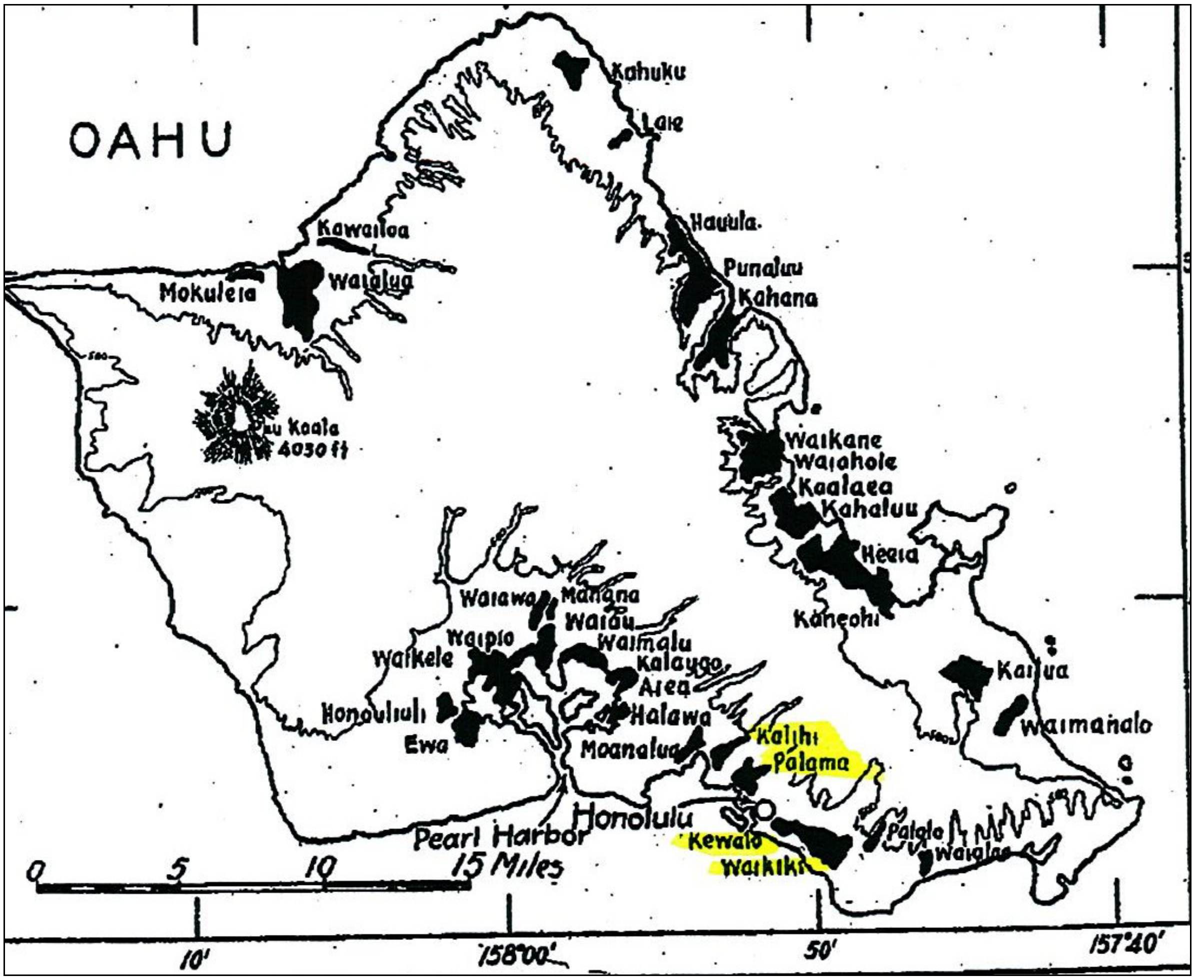

Figure 81. Coulter’s (1937:12) map of “Rice Farming Districts on Oahu 1892” (highlighting added to note indications of extensive rice cultivation in Kalihi, Pālama, Kewalo and Waikīkī)

9.3.3 Foraminifera Evidence of Water (Ponds and/or Marine Inundation)

The identifications of “Foraminifera” (large, chiefly marine, protozoans usually having calcareous shells) in the pollen record may be evidence of marine inundation. Although Foraminifera are primarily marine, some can survive in brackish water, which complicates the interpretation of the significance of their presence. Such marine inundation as might deposit Foraminifera evidence typically would arise from short term events such as tsunami, hurricanes, or storms but might also result from long-term natural processes of shore-line change. Foraminifera appear to have been identified in samples from ten test excavations (T-014, T-092, T-093, T-161, T-067, T-132, T-181, T-184, T-191, T-207; Cummings and Varney 2013: 41-43), submitted for pollen analysis.

The Pollen report appears to straddle this issue of just what the presence of Foraminifera means, for in the case of T-014 the conclusion is that: "Recovery of a few Foraminifera is consistent with use of this area for growing rice, as it is likely that at least some marine water entered this low-lying area." On the other hand, the conclusion for the presence of Foraminifera at T-181 was that "Foraminifera also were observed, which is consistent with the presence of a pond."

While the issue of whether Foraminifera indicate "marine water" or simply "a pond" is not altogether clear, it does seem clear that the Foraminifera at ten of the sampled test excavations indicate the prior presence of water sufficient for the growth of these protozoans.

9.3.4 Charcoal

The pollen analysis study identified microscopic charcoal fragments in all samples (Cummings and Varney 2013: 41-43) indicating widespread burning episodes. The authors suggest possible sources as including "burning the rice fields or perhaps nearby sugarcane fields or "to clear agricultural stubble, remains, or perhaps weeds" (Cummings and Varney 2013: 7, 10).

9.3.5 Evidence for Change Over Time

The carbon dating results from the City Center section AIS indicate that little time depth is documented in the test excavations. All (six) of the exclusively pre-Contact dates overlapped and had date ranges that clustered relatively tightly in the AD 1440–1660 period. It was somewhat surprising that no earlier dates were acquired (the oldest date range was AD 1440–1630). Furthermore no pollen samples were acquired from these earliest dated sediments. While it is possible that one or more of the pollen samples pre-dates the fifteenth century, we have no evidence to support that assumption. By the likely late pre-Contact to nineteenth century timeframe represented by the pollen samples, the ecosystem of the surrounding area would have undergone centuries of transformation as a result of direct human activities, the depredations of pigs, dogs, and particularly rats, and the deliberate and accidental spread of fire. Many of the pollen samples clearly indicate post-Contact environmental change as evidenced by the presence of pollen from exotic species.

Several of the pollen samples were from superimposed strata within a given test excavation. Test excavations that yielded superimposed pollen samples included T-067, T-080, T-093, T-132, T-161, T-191 and T-207 (see Cummings and Varney 2013: 41-43). Most pollen analysis categories had such low numbers of identifications as to make generalizations of change over time problematic. An effort to identify patterns of change over time in the abundance of Poaceae (grasses), charcoal, and Foraminifera indicated no clear pattern. The only pattern indicated was an increase of Cyperaceae with sample depth (believed to roughly correlate with time depth by the law of superimposition). The relative abundance of Cyperaceae appears to increase with depth in T-067, T-093, T-191, and T-207 (see Cummings and Varney 2013: 41-43). No clear countervailing trends (in other words a significant increasing abundance of sedges moving towards modern times) were observed. Notably there are virtually no sedges present in the City Center corridor environs today, which lends further support to the observed trend. There are many possible explanations for the decrease in sedges but the general explanation would appear to be that natural marshes are being transformed. These transformations almost certainly were associated with the clearing of natural marsh areas for fishponds, *loʻi kalo*, and/or rice paddies. This change probably reflects in part the deliberate infilling of marshy areas in the post-Contact period. Whether this also reflects loss of wetlands due to an increase in erosion and an increase in the rate of the filling of low-lying areas with sediments in later pre-Contact times is unclear (although this would seem likely). Although a trend towards a decreasing abundance of sedges approaching the present is indicated, it should be noted that throughout the pollen record documented here, Cyperaceae appears to be the largest contributor.

The most noted change in mesic dryland landscape in pre-contact Hawaiian times was the loss of *Pritchardia* (*loulu*) palms, which may have been quite abundant in such environs (see discussions above of the findings of Wickler et al. 1991 and Athens and Ward 1994). *Pritchardia* pollen was identified in low abundance in T-067, T-122, T-132, T-161, and T-207 and was a significant component of the pollen record in T-093. This suggests that the extirpation of the *Pritchardia* forests may not have been quite as conclusive as has been previously indicated.

9.3.6 Characterization of the Native Landscape

As noted above, Cyperaceae appears to be the largest pollen contributor, with Poaceaea a strong second in abundance. The environment indicated throughout the pollen record is one of sedges and grasses representing marshy land and grass lands. The next most abundant component is the "cheno-am," understood to be produced by a variety of dry land species such as *Chenopodium oahuense (ʻaweoweo* or goosefoot*)* and *Amaranthus* species. Wagner et al. (1990:536) insightfully describes *Chenopodium* species as "subshrubs" which captures their herbaceous, "rarely woody," and weedy nature. Cuddihy and Stone (1990:12) characterize such a landscape as dry leeward lowland grasslands and shrublands. They posit that dominant grass species might have included *pili* (*Heteropogon contortus*), *kākonakona* (*Panicum torridum*) and ʻ*emoloa* (*Eragrostis variabilis*), and that a common sedge might have been *Fimbristylis cymosa* (*mauʻu*), which Wagner et al. (1990:1405) describes as "common on sandy beaches, and in shallow sand or soil on and among rocks and cracks." Cuddihy and Stone (1990:12) note that such extensive lowland grasslands "were probably largely the result of the Hawaiian practice of burning." Clearly pre- and post-Contact agriculture and post-Contact grazing also were factors.

While this data alone suggests the landscape was a somewhat monotonous plain of grasses, sedges, and weedy cheno-am subshrubs, a complete picture must acknowledge that a significant species diversity is in fact represented. Cuddihy and Stone (1990:12) posit that "Native shrubs that are dominants in these communities" included *ʻaʻaliʻi* (*Dodonaea viscosa*), *ʻākia* (*Wikstromia* sp.), *ʻaweoweo* (*Chenopodium oahuensis*), *koʻokoʻolau* (*Bidens menziesii*), *pūkiawe* (*Styphelia tameiameiae*), *alaheʻe* (*Canthium odoratum*), low-growing *ʻōhiʻa* (*Metrosideros polymorpha*) and possibly also *ʻakoko* (*Chamaesyce* sp.), *nehe* (*Lipochaeta* sp.), *kuluʻi* (*Nototrichium sandwicense*), and *ʻohai* (*Sebania tomentosa*). This posited list of dominants actually has fairly minimal overlap with the pollen taxa identified in the City Center Section (compare preceding listing with that in Table 270 from the present project). This suggests that the shrubs and trees of this grassland may have been more diversified than previously understood.

POLLEN ANALYSIS OF SAMPLES FROM THE HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT, HONOLULU, HAWAI'I

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INTRODUCTION

Pollen analyses collected from sediments exposed in trenches for the Kalihi 22 project were conducted in an effort to define the past environment and identify evidence of agriculture. The project is located in the greater Waikiki area on the south shore of Oahu. Three submissions of samples from a variety of trenches have been analyzed.

METHODS

Pollen

A chemical extraction technique based on flotation is the standard preparation technique used in this laboratory for removing pollen grains from the often large volume of sand, silt, and clay with which they are mixed. Since experience of working with sediments from this area has shown that total pollen concentration is usually in the thousands of pollen per cubic centimeter (cc) of sediment, if not the tens of thousands of pollen per cc of sediment, relatively small quantities of sediment (5 to 15 cc) were selected from each sample. The more organic the sediment the smaller the sample volume.

Hydrochloric acid (10%) was used to remove calcium carbonates (shell) present in the sediment, after which the samples were screened through 250-micron mesh. The samples were rinsed until neutral by adding water, letting the samples stand for 2 hours, then pouring off the supernatant. A small quantity of sodium hexametaphosphate was added to each sample once it reached neutrality, then the samples were allowed to settle according to Stoke's Law in settling columns. This process was repeated with ethylenediaminetetraacetic acid (EDTA). These steps remove clay prior to heavy liquid separation. The samples then were freeze dried. Sodium polytungstate (SPT), with a density of 1.8 g/ml, was used for the flotation process. The samples were mixed with SPT and centrifuged at 1,500 rpm for 10 minutes to separate organic from inorganic remains. The supernatant containing pollen and organic remains was decanted. Sodium polytungstate again was added to the inorganic fraction to repeat the separation process. The supernatant was decanted into the same tube as the supernatant from the first separation. This supernatant then was centrifuged at 1,500 rpm for 10 minutes to allow any remaining silica to be separated from the organics. Following this, the supernatant was decanted into a 50-ml conical tube and diluted with distilled water. These samples were centrifuged at 3,000 rpm to concentrate the organic fraction in the bottom of the tube. This pollen-rich organic fraction was rinsed, then all samples received a short (20–30 minute) treatment in hot hydrofluoric acid to remove any remaining inorganic particles. The samples were acetylated for 3–5 minutes to remove any extraneous organic matter.

A light microscope was used to count pollen at a magnification of 500x. Pollen preservation in these samples varied from good to poor. Comparative reference material collected at the Intermountain Herbarium at Utah State University and the University of Colorado Herbarium was used to identify the pollen to the family, genus, and species level, where possible.

Pollen aggregates were recorded during identification of the pollen. Aggregates are clumps of a single type of pollen and may be interpreted to represent either pollen dispersal over short distances or the introduction of portions of the plant represented into an archaeological setting. The aggregates were included in the pollen counts as single grains, as is customary. The presence of aggregates is noted by an "A" next to the pollen frequency on the pollen diagram. The pollen diagram was produced using Tilia 2.0 and TGView 2.0.2. Total pollen concentrations were calculated in Tilia using the quantity of sample processed in cubic centimeters (cc), the quantity of exotics (spores) added to the sample, the quantity of exotics counted, and the total pollen counted and expressed as pollen per cc of sediment.

"Indeterminate" pollen includes pollen grains that are folded, mutilated, or otherwise distorted beyond recognition. These grains were included in the total pollen count since they are part of the pollen record. The microscopic charcoal frequency registers the relationship between pollen and charcoal. The total number of microscopic charcoal fragments was divided by the pollen sum, resulting in a charcoal frequency that reflects the quantity of microscopic charcoal fragments observed, normalized per 100 pollen grains.

Pollen extraction retains starch granules, which are reported when observed while counting pollen. An additional search for starches is performed only when starch analysis is part of the suite of analyses performed. Starch granules are a plant's mechanism for storing carbohydrates. Starches are found in numerous seeds, as well as in starchy roots and tubers. The primary categories of starches include the following: with or without visible hila, hilum centric or eccentric, hila patterns (dot, cracked, elongated), and shape of starch (angular, ellipse, circular, eccentric). Some of these starch categories are typical of specific plants, while others are more common and tend to occur in many different types of plants.

ETHNOBOTANIC REVIEW

It is a commonly accepted practice in archaeological studies to reference ethnographically documented plant uses as indicators of possible or even probable plant uses in prehistoric times. The ethnobotanic literature provides evidence for the exploitation of numerous plants in historic times, both by broad categories and by specific example. The presence of numerous sources of evidence for exploitation of a given resource can suggest widespread utilization and strengthens the possibility that the same or similar resources were used in prehistoric times. Ethnographic sources both inside and outside the study area have been consulted to permit a more exhaustive review of potential uses for each plant. Ethnographic sources document that the historic use of some plants was a carryover from the past. A plant with medicinal qualities is likely to have been discovered in prehistoric times, with its use persisting into historic times. There is, however, likely to have been a loss of knowledge concerning the utilization of plant resources as cultures moved from subsistence to agricultural economies and/or were introduced to European foods during the historic period. The ethnobotanic literature serves only as a guide indicating that the potential for use existed in prehistoric times, not as conclusive evidence that the resources were used. Pollen, phytoliths, starch, and macrofloral remains, when compared with the material culture (artifacts and features) recovered by the archaeologists, can become indicators of use. Plants represented by pollen will be discussed in the following paragraphs to provide an ethnobotanic background for discussing the remains.

Cultigens

Colocasia (Taro)

Taro was usually grown as an aquatic, and water was diverted from nearby streams to flow through terraced agricultural fields (*loi*). It is important to remember that "by the end of the century, it was noted that about half of the production of taro was by Chinese farmers and that 80 per cent of the poi manufacturing was done by the Chinese. This trend has now gone further, to the point where practically all poi manufacturing is in the hands of the Chinese, and Hawaiians constitute much less than half of the taro producers. At the present time, taro production for poi making purposes occupies only about 1500 acres of land, which is small in contrast to the total area which must have been devoted to this crop in the ancient days. Much of our present production is by Japanese farmers who grow not only the so-called Japanese taro, a dryland type with relatively small corms used as a vegetable, but in many cases are producing ordinary taro for the poi factories" (Crawford 1937:269).

It is important to note the passage of taro cultivation from Hawaiians to Chinese and Japanese in the Hawaiian Islands near the turn of the century when considering evidence for agricultural practices and specifically for the potential of recovering *Colocasia* pollen. Modern taro farmers do not allow the taro to flower, and apparently taro flowers have been lost as part of the Hawaiian diet since approximately the turn of the century. However, this modern practice cannot be assumed to have held true for Hawaiian taro agriculture prior to 1900.

Water diversion for taro agriculture was so important that the "early Hawaiians became skillful engineers in manipulating rivers and streams to bring them through their cleverly terraced taro lands. Their system of water rights, protecting the individual farmer in an exceedingly complicated network of irrigation canals and ditches, was so eminently fair and effective that it was incorporated bodily into the new set of laws established when the Islands were annexed to the United States" (Crawford 1937:268).

Complex water diversion practices are important when considering origin of pollen in taro fields. Water readily transports pollen grains that can be deposited on it at any time from its source until it reaches the location sampled. Therefore, observation of pollen types from vegetation communities at a considerable distance upstream is expected in the pollen records of low elevation taro fields.

Gossypium (*Pulupulu-haole,* Cotton)

Gossypium barbadense (sea-island cotton) has been grown ornamentally in Hawai'i. Neal (Neal 1965:565) notes that cotton has not been grown successfully as a crop due to attacks by the pink bollworm and the tendency for cotton to grow into large perennials. *Gossypium hirsutum* (upland cotton) is a smaller, shrubby plant. *Gossypium arboreum* (tree cotton of India) is attached to legends from the Philippines. *Gossypium tomentosum* (native cotton, *ma'o, huluhulu*) is a native plant on the coasts of Hawai'i (Neal 1965:565).

Oryza (*Laiki*, Rice)

Oryza sativa (*laiki*, rice) is one of six tropical species of rice that grows as either an annual or perennial swamp grass. Most rice fields are terraced to benefit from elaborate irrigation systems. "When the grains begin to ripen and the panicle droops with their weight, the water is drained from the field to hasten the harvest" (Neal 1965:69). Rice seed probably was introduced to Hawai'i from china in 1856. More suitable seed was brought from South Carolina in 1860, and by 1862 rice was the second most important crop in Hawai'i. This economic importance was short-lived, as it yielded to coffee in 1899, largely because of the ancient and rather impractical methods of rice culture, milling, and marketing used in Hawai'i (Neal 1965:71).

DISCUSSION

The Kalihi 22 project includes an urban area in the vicinity of the Ala Moana shopping center. Several test trenches were used to examine the prehistoric sediments in the area. Four of these trenches (T-080, T-132, T-191, and T-207) were selected for preliminary pollen analysis. Each is represented by three samples collected within Stratum II (Table 1, Figure 1). Additional trenches in the city center section were examined along Dillingham Blvd., Kokea Street, and Ward Avenue. Trenches in the airport section also were examined, specifically along Kamehameha Highway, Nimitz Highway, and Honolulu International Airport. Results of this analysis will be discussed separately, by trench, below.

[a bottom portion of page 4, the entirety of page 5 and a top portion of page 6 pertaining exclusively to pollen from the Airport Section have been deleted]

City Center Section

Trench 014

Trench 014 was placed along Kamehameha Highway. Sediments included alluvial silty clay loam containing abundant organics and water-rounded gravel. This area is part of a land commission award and was considered to be a likely area for growing taro, and later, possibly rice. A single pollen sample was collected from Stratum II at a depth of 180-207 cm. Pollen representing aliens including *Leucaena* and *Prosopis* (Figure 3, Table 1), representing *koa haole* and *kiawe*, indicates this sample either represents historic sediments or that this level was contaminated by historic sediments. This sample was dominate by Poaceae pollen, most of which is consistent in morphology with that produced by *Oryza*, suggesting rice cultivation. Cheno-am pollen was abundant, suggesting growth of *'aheahea* on the drier sediments surrounding this area. Recovery of small quantities of Cyperaceae pollen suggest that sedges also grew in or at the edge of the rice paddy, but were not particularly abundant, at least in the area sampled. Recovery of small quantities of *Cocos nucifera*, *Myrsine*, Myrtaceae, *Sida*, Low-spine Asteraceae, High-spine Asteraceae, Liguliflorae, Brassicaceae, and *Broussaisia*-type pollen indicate local growth of *niu*, *kōlea*, trees in the myrtle family, *'ilima*, members of the sunflower family including the chicory tribe, plants in the mustard family, and *kanawao*. This sample also exhibits a moderately large quantity of microscopic charcoal suggesting the possibility that the rice fields were burned, which is echoed by recovery of small quantities of charred grass stems and fragments of plants in the sunflower family. Fern spores were present, but not particularly abundant, suggesting growth of some ferns along the periphery of the ponded area. Recovery of a few Foraminifera is consistent with use of this area for growing rice, as it is likely that at least some marine water entered this low-lying area. Total pollen concentration was moderate at slightly more than 19,000 pollen per cc of sediment.

Trench 041

Trench 041 was located within Dillingham Blvd. Alluvial silty clay loam contained charcoal flecking. Historic maps of this area indicate taro fields as well as a rice plantation in this area. A single sample was collected and analyzed from a depth of 46-64 cm from Stratum II. This sample was dominated by Cheno-am pollen, suggesting a sizeable population of *Chenopodium oahuense* (*'aheahea*) growing in the area. This suggests a relatively dry habitat

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was sampled. In addition, small quantities of *Pelea*, *Broussaisia*, *Sida*, High-spine Asteraceae, Liguliflorae, Cyperaceae, *Euphorbia*, Poaceae, and *Vigna* pollen represent *kukaemoa*, *kanawao*, *'ilima*, various members of the sunflower family, sedges, spurge, grasses, and *mohihihi* or beach pea grew in the area. This sample also contained both *Oryza* and *Colocasia* pollen, indicating that the rice and taro agriculture noted on the historic maps can be verified for this area. It is interesting that there is such a minor signature for other plants that usually populate wet areas, such as sedges. This suggests the possibility that specific fields were located in this area that were tended and weeded. *'Aheahea* would have grown in drier sediments outside the ponds. Pollen from these shrubby plants is produced in abundance and travels readily on the wind. Recovery of *Leucaena* and *Prosopis* pollen from this sample indicates that this deposit is part of the historic record. Fern spores were present, but in small quantities. Microscopic charcoal also was present, but not abundant. Charred Poaceae (grass) leaf fragments were observed, but also were note abundant, suggesting the possibility that local fields were burned. Total pollen concentration was relatively low at just under 2,000 pollen per cubic centimeter (cc) of sediment.

Trench 067

Trench 067 was located within the community college lawn on Kokea Street, very close to Kapalama Stream. The sediments from Stratum II were silty clay typical of wetlands in a stream floodplain. This area might have been used for taro and/or rice fields. The pollen record is very different from that noted in Trench 41. In this location Cyperaceae pollen was dominant, indicating a well established wetland that supported a large sedge population. Most of the rest of the pollen taxa recovered in the three samples examined from Stratum II were noted in very small quantities. Small quantities of *Vigna* pollen were noted in the upper two samples in this trench. Neal (Neal 1965:468) notes that *Vigna sinensis* (cow pea) was introduced, probably from southeastern Asia. This vining legume produces green pods that measure between 8 and 12 inches long. These beans are used in Chinese cooking and have been termed yard-long beans. Recovery of *Vigna* pollen from this location suggests use of this area for growing these beans.

Moderately large quantities of *Oryza*-type pollen were recovered from all three of these samples, suggesting rice fields were located in the wetlands along Kapalama Stream. Recovery of *Typha angustifolia*-type pollen in the two upper samples indicates that non-agricultural wetland vegetation including cattails also grew in the area. A single *Saccharum* pollen grain was observed in the lowest sample examined from Stratum II. This indicates the presence of a sugar cane field within close proximity to the stream, as well. It could have been located several tens of meters from this area along the stream. Ferns are documented to have been moderately abundant in this area, as expected. Only a few Foraminifera fragments were observed in the lower two samples from this location. It is possible that they traveled inland with storm surge and were deposited in this area. None of the foraminifera observed consisted of more than a few units along the spiral. Charred Poaceae (grass) fragments were moderately abundant in the sediments from this location, suggesting burning the rice fields or perhaps nearby sugarcane fields. Other microscopic charcoal fragments were not as abundant. Total pollen concentration was much higher in this location, varying from nearly 14,000 to almost 42,000 pollen per cc of sediment. This is more consistent with quantities expected in wetlands, whether they represent a marsh or agricultural fields.

Trench 080

This trench was located within Dillingham Blvd. The stratigraphic provenience is described as including silty clay sediment that contained freshwater snails, wood, and grass in Stratum II) that might represent rice field deposits overlying previous Hawaiian wetland cultivation or perhaps natural wetlands.

Pollen analysis of these samples provides supporting evidence for the presence of wetlands. Cyperaceae pollen (Figures 1 and 2, Table 3) was dominant in samples from the city center section, followed by moderate quantities of Poaceae and Cheno-am pollen. Grasses probably would have included a variety of wetland grasses that grew mixed with the sedges. Cheno-am pollen probably represents *Chenopodium oahuense* (*'aheahea*), a shrub that would have grown in a drier setting outside the wetland. Large size Poaceae pollen was observed in the upper two samples suggesting the possibility that either sugar cane was grown in the area or that *pili* grass grew locally. Small quantities of *Typha* pollen were observed in all three samples, with the largest quantity noted in the lowest sample. Cattails are expected to be part of the population of local wetland plants. *Cocos nucifera* pollen was observed in the middle sample from this trench, indicating the presence of coconut trees growing in this general area. *Sicyos* pollen was observed in the lowest sample. These endemic vines may grow from the coast well into the mountains and occupy a variety of habitats (Wagner et al. 1990:573-581). *Commelina* pollen was observed only in sample T-080-4. *Honohono* has been naturalized in Hawai'i. This plant, which is native to tropical Asia and Africa, grows in both dry and wet habitats. *Honohono* usually grows in disturbed areas. The earliest collection of *Commelina diffusa* was made in 1837 (Wagner et al. 1990:1379). It is this recovery of *Commelina* pollen that provides a possible date of mid to late nineteenth century (or later) for the middle sample from this trench. The presence of *Commelina* pollen lends interpretive value supporting a date during the historic era to the small quantities of *Prosopis* pollen observed in samples from this trench, since *kiawe* pollen was noted only in the upper two samples.

Samples examined from the airport section tended to be dominated by Cheno-am pollen or not to have any single dominant pollen taxon. Poaceae pollen also was abundant in many of the samples from the airport section. High-spine Asteraceae pollen, while present, was dominant in only one sample.

Most other pollen types noted were observed in very small quantities. The only pollen noted that represents agricultural activity was *Colocasia*, representing taro cultivation. It was observed in the upper sample from this trench. It is possible that the *Commelina* pollen recovered from the lower sample relates to use of this area as an agricultural field, as *honohono* often grows in disturbed areas such as agricultural fields. No grass pollen that could be positively ascribed to rice was observed. Distinction between rice and other grass pollen is made on a combination of size and surface characteristics. Grass pollen sizes tend to overlap, so do not provide as robust an identification criterion as do phytoliths. Rice produces both a distinctive buliform phytolith and also an arrangement of the bilobates in the leaves when the cells have not been broken apart by post-depositional processes. Phytoliths provide a much more robust interpretation of the presence or absence of rice agriculture. Additional phytolith analysis of samples from this location is recommended to answer this question more fully. Phytolith analysis is also recommended for any other locations where identifying rice agriculture is important.

Evidence for pollen representing alien plants is limited to a very few *Prosopis* pollen observed in the upper two samples. Either these pollen indicate that these depths represent historic deposits or they are present through downward intrusion into the sediments.

Spores were present in small quantities in each of these samples, indicating that local vegetation also included a variety of ferns. Quantities of microscopic charcoal increased through time, as the largest quantity was observed in the upper sample. A few charred grass cells were noted in the upper and lower samples. Total pollen concentration was very high at more than 60,000 pollen per cubic centimeter (cc) of sediment in each of these samples.

Trench 092

Trench 092 is located at Kaaahi Street within an automotive shop parking area. A single sample was collected from Stratum II at a depth of 173-183 cm, which represents marine clay within the historic *Kuwili* fishpond, which has been covered by fill deposits. This pollen record was dominated by Cyperaceae pollen, indicating that the fishpond supported a rather large population of sedges, perhaps around the edges. In addition, a moderate quantity of Poaceae pollen was observed, much of which is consistent in morphology with that produced by *Oryza*, suggesting the possibility of intermittent use of this fishpond for growing rice. Small quantities of *Colubrina*, *Myrsine*, Myrtaceae, *Charpentiera*, Cheno-am, *Dodonaea*, *Kadua*, *Sida*, *Walthera*, High-spine Asteraceae, Brassicaceae, *Rumex*, and *Prosopis* pollen indicates local growth of a variety of trees, shrubs, and herbaceous plants that would have included at least *kauila*, *kōlea*, a member of the myrtle family, *pāpala*, probably *‘aheahea*, *‘a’ali’i*, *‘awiwi*, *‘ilima*, *‘uhaloa*, various members of the sunflower and mustard families, and the aliens sorrel and *kiawe*. Fern spores were not particularly abundant in this area. Microscopic charcoal was present, but not abundant. Foraminifera were observed in a moderately small quantity. Total pollen concentration was moderate at slightly more than 18,000 pollen per cc of sediment.

Trench 093

Trench 093 is located within the sidewalk at Kaaahi Street. Two samples were examined from this trench, representing Strata IIa and IIb at depths of 182-229 and 250-274 cm, respectively. These two strata represent silty clay wetland sediments within the historic *Kuwili* fishpond, now covered by fill. These two samples display slightly different pollen signatures. Sample T-093-2, representing the lower Stratum IIb, is dominated by Cyperaceae pollen, indicating local growth of an abundance of sedges either within the fishpond or near the edges. In the upper sample moderate increases in a variety of other pollen types offset the reduction in Cyperaceae pollen, indicating the possibility that the water was more open. Both samples exhibited pollen morphologically consistent with that produced by *Oryza*, suggesting growing rice in this wetland. Whether the rice was grown intermittently in the ponds that also were used or sometimes were used as a fish pond is difficult to determine. A single pollen grain of *Colocasia*-type pollen from the lower sample, indicates growth of taro at least occasionally, in this location. The lower sample also contains small quantities of Anacardiaceae, *Antidesma*, *Bobea sandwicensis*-type, *Cordyline*, *Myrsine*, Myrtaceae, *Pelea*, *Pritchardia*-type, Rhamnaceae, Cheno-am, *Dodonaea*, *Sida*, Low-spine Asteraceae, High-spine Asteraceae, Brassicaceae, *and Euphorbia*, indicating local growth of a member of the sumac family such as mango, *hame*, *‘ahakea*, *ti*, *kōlea*, a member of the myrtle family, *kukaemoa*, *loulu*, a member of the buckthorn family, probably *‘aheahea*, *‘a’ali’i*, *‘ilima*, various members of the sunflower and mustard families, and *kaliko*. The upper sample exhibited moderate quantities of *Pritchardia*,

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Cheno-am, Cyperaceae, and *Oryza* pollen representing *loulu*, probably *'aheahea*, sedges, and rice. In addition, the upper sample contained small quantities of *Acacia*, *Morinda*, *Zanthoxylum*, *Kadua*, *Eriogonum*, and *Casuarina* pollen that were not present in the lower sample. These pollen represent acacia, *noni*, *a'e*, *au*, wild buckwheat, and Australian pine.

Fern spores are present in both samples, but not abundant, suggesting growth of ferns around at least part of the margin of this pond. A very small quantity of small microscopic charcoal pieces were observed in each of the samples from this pond. Foraminifera were noted only in the lower sample. Total pollen concentration varied from more than 10,000 pollen per cc of sediment in the lower sample to nearly 27,000 pollen per cc of sediment in the upper sample.

Trench 122

Trench 122 is located on Halekauwila Street. Wetland sediments in this area have the potential to contain agricultural evidence. Historic maps indicate the presence of a pond. A single pollen sample was collected from Stratum II at a depth of 165-170 cm. This sample contained *Cocos nucifera* and *Prosopis* pollen as co-dominants, representing *nui* and *kiawe*, the latter an alien tree. Other pollen representing aliens includes small quantities of *Casuarina* and *Leucaena*, representing Australian pine and *koa haole*. In addition, the wetland supported sedges, as evidenced by recovery of a moderately small quantity of Cyperaceae pollen. A portion of the Poaceae pollen is consistent morphologically with that produced by *Oryza*, suggesting use of this pond for growing rice. Small quantities of *Antidesma*, *Myrsine*, Myrtaceae, *Pritchardia*-type, Cheno-am, *Dodonaea*, Solanaceae, High-spine Asteraceae, Brassicaceae, *Cressa*, *Bonamia*, and *Tribulus* indicate local growth of *hame*, *kōlea*, a member of the myrtle family, *loulu*, probably *'aheahea*, *'a'ali'i*, a member of the nightshade family, members of the sunflower and mustard families, cressa, *kokolau*, and *nohunohu*. This sample contained only a few fern spores suggesting that ferns were not abundant in the vicinity of this pond. It did exhibit a moderately large quantity of microscopic charcoal, suggesting burning either to clear agricultural stubble, remains, or perhaps weeds. The total pollen concentration was more than 13,000 pollen per cc of sediment.

Trench 132

Trench 132 was located in the Halekauwila Street parking lot. Stratum II at this location is described as sandy silty clay sediment containing organics and is thought to represent a possible natural coastal wetland. The three samples examined from this location were dominated by Poaceae pollen, with much smaller quantities of Cyperaceae pollen, indicating a local habitat dominated by grasses and also including sedges. The quantity of Cheno-am pollen noted in each of these samples was reduced compared to the quantities noted in most of the other samples examined from this project to date. Only a small quantity of *Typha* pollen was noted in the uppermost sample from this location. Most of the other pollen observed was noted in very small quantities. *Acacia* pollen was observed in small quantities in the upper and lower sample from this trench, documenting local growth of *koa*. Recovery of a small quantity of *Cocos nucifera* pollen in the upper sample represents local growth of coconut trees in the area at the time these sediments accumulated. No evidence of agriculture was noted in any of these samples.

Interestingly, all three of these samples contained *Prosopis* pollen, representing the alien *kiawe*. In addition, a small quantity of *Leucaena* pollen were noted, representing *koa* *haole*. The *Tribulus* pollen observed in this sample might represent either the alien or the indigenous plant. Due to the sandy nature of these samples it is possible there was downward intrusion of pollen from more recent vegetation above.

Spores were present in small quantities, which is consistent with a local population of ferns. Total pollen concentrations were widely variable in these samples with the lower deposits hovering around 9,000 to 10,000 pollen per cc of sediment and the upper sample weighing in at nearly 26,000 pollen per cc of sediment. Lower total pollen concentrations are consistent with sandy sediments.

Larger quantities of microscopic charcoal were observed in these three samples, with the lowest sample exhibiting the largest quantity. Small quantities of foraminifera and a scolecodont (polychaete worm jaw fragment from an annelid worm) were noted in this sample, which are consistent with inundation of these sediments with marine water.

Trench 161

Trench 161 was located within the parking lot of Ross-Dress-for-Less at Ward Avenue. This area is described as typical of wetland sediments. Organic matting that might have had an agricultural function was observed at its upper boundary. The lowest sample represents the Stratum IIa/IIb interface and the upper two samples represent Stratum IIa. The pollen record is dominated by Cyperaceae pollen in all three of the samples examined. The lowest sample also contained moderate quantities of Fabaceae and Poaceae pollen, suggesting growth of a legume and grasses along the margins of the wetland. Very small quantities of Poaceae pollen that exhibited the characteristics typical of *Oryza* (rice) were observed in each of these three samples. It is possible that rice was grown in this area, but that use of these wetlands for rice fields did not persist over time. Quantities of charred Poaceae (grass) fragments were very small in these sediments, also suggesting limited use of this area for wetland agriculture. A single Spirogyra algal spore also was noted in the lowest sample from this trench. The middle sample yielded the largest quantity of Cyperaceae pollen, which suggests the presence of a sedge marsh in this area. The uppermost sample yielded a diminished quantity of Cyperaceae pollen, offset by a large increase in *Myrsine* pollen, reflecting *kōlea* trees growing in or at the edges of the wetlands. This pattern is probably associated with a change in the marsh, such as more open water and a smaller sedge population. This also might reflect clearing some of the sedges and use of the wetland for another purpose, such as a taro field. Unfortunately, no *Colocasia* pollen was observed in this sample to substantiate such a use. Spores were present in increasing quantities from the base to the top of this record, suggesting an increase in the local fern population through time. Microscopic charcoal and charred Poaceae (grass) fragments were present, but not abundant in samples from this trench.

Trench 181

Trench 181 is located at Queen Street. Sandy clay wetland sediment in this area contains peat layers and organics. Historic maps indicate this trench cut through *Kolowalu* fishpond. A single sample was collected from Stratum II at a depth of 120-130 cm. The pollen record was dominated by *Myrsine* pollen, suggesting open water and wind transport of pollen from *kōlea* trees growing nearby. Recovery of a moderate quantity of Cyperaceae pollen indicates that sedges grew at least around the margins of the pond. Small quantities of *Cocos nucifera*, *Ilex*, *Pritchardia*-type, Cheno-am, High-spine Asteraceae, Brassicaceae, Poaceae, *Casuarina*, *Leucaena*, and *Prosopis* pollen suggest that local vegetation included at least *niu*, *'aiea*, *loulu*, probably *'aheahea*, members of the sunflower and mustard families, grasses, and several aliens that included Australian pine, *koa haole*, and *kiawe*. Evidence for ferns was sparse. Microscopic charcoal was present, but not abundant. Foraminifera also were observed, which is consistent with the presence of a pond. Total pollen concentration was high at more than 63,000 pollen per cc of sediment.

Trench 184

Trench 184 is located at Waimanu Street. This location also is within the historic *Kolowalu* fish pond. Sediments are described as sandy clay wetland sediments. Freshwater/brackish snails were observed. The pollen record for this portion of the pond was dominated by Cyperaceae pollen, indicating growth of sedges in this area. A small quantity of large grass pollen was observed, but it is not consistent, morphologically, with that produced by *Oryza* (rice). Small quantities of Anacardiaceae, *Cocos nucifera*, *Myrsine*, Cheno-am, *Sida*, *Heliotropium*, *Bonamia*, and *Prosopis* pollen indicate the presence of a member of the sumac family such as mango, *niu*, *kōlea*, probably *'aheahea*, *'ilima*, *hinahina*, *kokolau*, and *kiawe*. A large quantity of microscopic charcoal was noted in this sample, suggesting burning either agricultural stubble or weeds. Foraminifera also were present, as they were in Trench 181. Total pollen concentration was lower in this portion of the pond at nearly 27,000 pollen per cc of sediment.

Trench 191

Trench 191 was located along Kona Street west of the Ala Moana Center Station. Deposits in this area were sandy clay in Stratum IIa and clay in Stratum IIb. Stratum IIb likely represents a former marsh or wetland and sits just above the modern water table. The pollen record from this trench was heavily dominated by Cyperaceae pollen, representing a local population of sedges growing in a marsh. It is interesting that there is little difference in the pollen content of the samples from the IIb and IIa sediments. Poaceae pollen was noted in much smaller quantities, suggesting that there were few grasses mixed with the sedges in this marsh. Cheno-am pollen indicates that *'aheahea* likely grew in drier sediments somewhat removed from the marsh. *Acacia* pollen was observed in the uppermost sample, indicating that *koa* grew in the area. Recovery of very small quantities of a variety of other pollen taxa from these sediments is typical of the pattern observed in other samples and represents general pollen rain probably derived from wind transport. It is interesting that very small quantities of *Prosopis* pollen were observed in each of these samples. It is likely that these represent intrusion of relatively modern pollen, either through rare downward movement through the sediments or perhaps introduced at the time of sample collection. The pattern observed in these samples does not suggest severe contamination of the pollen record by modern or recent pollen. No evidence of agricultural activity was noted in samples from this trench.

Spores representing ferns were observed, but not particularly abundant. Microscopic charcoal was not abundant in these samples, with the exception of the uppermost sample. Foraminifera were much more common in these samples than in samples from Trenches 080 or 132, suggesting more regular inundation of these sediments. Total pollen concentration was moderately high, which is typical of marshes. It varied between nearly 20,000 and more than 23,000 pollen per cc of sediment.

Trench 207

This trench was also located on Kona Street, this time at the Ala Moana Mall. Samples were collected entirely from Stratum IIa, which is described as sandy clay sediment that contained organics and freshwater snails. It is likely that this area also was a former marsh or wetland. The pollen record again was dominated by Cyperaceae pollen, as was the record at T-191. Increasing quantities of Poaceae and Cheno-am pollen, accompany by declining quantities of Cyperaceae pollen indicate that these sediments dried out through time, but still were sufficiently wet to support a sedge marsh for the entire time period represented. Ferns were more abundant in the upper two samples, as the sediments dried, suggesting that they grew best when the marsh began to dry out. *Acacia* pollen was observed in the upper two samples from this trench, indicating local growth of *koa*.

Total pollen concentration also supports this interpretation, as it was high at approximately 83,000 pollen per cc in the lower sample and the reduced greatly to only approximately 6,500 pollen per cc in the middle sample. This was accompanied by evidence of fire in the middle sample, which displayed the largest quantity of microscopic charcoal observed in samples from this trench.

Once again very small quantities of *Prosopis* pollen were noted in each of these samples, but the quantity does not appear to be sufficient to indicate a problem with the record as a whole.

SUMMARY AND CONCLUSIONS

The pollen record for each of the trenches provides relatively point-specific information. This overview ties together observations concerning use of the landscape, as evidence by recovery of pollen representing agricultural crops.

Colocasia pollen was observed in the uppermost sample from T-080, indicating taro agriculture in this location. Recovery of *Commelina* pollen in sample T-080-4, below the one containing taro, indicates that taro agriculture was part of the historic use of this area. In addition, *Colocasia* pollen was noted in T-041 and T-093-2, further documenting taro agriculture in these locations. In T-041 it was accompanied by *Leucaena* and *Prosopis* pollen, indicating that taro agriculture was part of the historic record. In T-093-2 no alien pollen was observed, providing the only record of early taro agriculture from this study.

Evidence for rice agriculture was more widespread. This is due to the fact that grasses, including rice, produce fairly large quantities of pollen that are distributed by the wind at least within short distances. Rice agriculture is suggested for T-014, T022, T–033, T-041, T-067, T-092, T-093, T-122, and probably T-181. The very small quantities of *Oryza*-type pollen recovered in samples from Trench 161 might represent rice agriculture in the area, but not this specific location, or might represent short-term use of the wetland for rice agriculture before switching to another crop or perhaps abandoning the wetland as an agricultural field. Identification of *Oryza* pollen is based on a combination of size and surface sculpturing. When other grasses with similar pollen grow in an area, this identification can be somewhat tenuous. Therefore, *Oryza* pollen was not separated from that of other grasses for samples in

Submission 1. Phytolith analysis provides more certain identification of the presence of rice because the orientation of bilobate phytoliths in rice leaves is unique.

Taro pollen was noted in samples from Trenches 041 and 093 along with rice pollen, indicating sampling areas that had been used to grow both taro and rice, not necessarily simultaneously.

Trenches in areas identified as probable marshes (T-067, T-080, T-092, T-093, T-161, T-184, T-191, and T-207) exhibited Cyperaceae as the dominant pollen type, indicating that these areas were sedge marshes. The areas represented by T-080 and T-093 appear to have been used as a taro field. Sedges also dominated the record in Trenches 067 and 161, which were noted to represent a wetland along Kapalama Stream and wetlands that might have had an agricultural function. The sample examined from T-181, which is part of *Kolowalu* fishpond, appears to represent open water. The sample from T-184, also representing *Kolowalu* fishpond, records a large sedge population, so it might be located closer to the edge of the fishpond.

Pollen representing other cultigens includes *Gossypium*, suggesting cotton cultivation at T-022 and T-933. As well as a single grain of possible *Saccharum* pollen noted in the lowest sample from T-067, suggesting sugar cane cultivation in the area.

Pollen representing alien plants includes *Casuarina*, *Commelina*, *Leucaena*, *Prosopis*, representing Australian pine, commelina, *koa haole*, and *kiawe*. Many of the samples examined exhibited one or more of these types of pollen representing alien plants, suggesting sampling many historic fishponds and agricultural areas.

Two types of *Acacia* pollen were observed in these samples. Pollen ascribable to *Acacia koa* was noted in samples T-191-1, T-207-2, and T-207-6. Trenches 191 and 207 were located to the West of the Ala Moana shopping center and in a parking lot of the Ala Moana shopping center. Proximity of these trenches is consistent with *Acacia koa* growing in this portion of the project area. *Acacia koa* pollen was also noted in samples from the Airport Section (Trenches 022 and 033). The other *Acacia* pollen could not be identified to species.

Trench 006 contained cobbles and stones in the single Stratum II sample submitted, which have been interpreted, along with the near absence of pollen, to represent a fast moving stream in this location. It appears the Wailolowai streambed was sampled.

TABLE 1
PROVENIENCE DATA FOR SAMPLES FROM
HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT, CITY CENTER SECTION

Trench	Column Sample No.	Depth (cmbs)	Stratum	Description/ Provenience	Analysis
Submission 1:					
T-080	1	140-143	II	Silty clay sediment containing freshwater snails, wood and grass (Stratum II)– possibly representative of rice field deposits overlying previous Hawaiian wetland cultivation and/or natural wetlands.	Pollen
	4	163-167			Pollen
	6	185-188			Pollen
T-132	1	137-139	II	Sandy silty clay sediment containing organics (Stratum II)– possible natural coastal wetland sediment.	Pollen
	2	142-144			Pollen
	3	147-149			Pollen
T-191	1	85-90	IIa	Sandy clay (Stratum IIa) and clay (Stratum lib) sediment– likely former marsh/wetland.	Pollen
	5	105-110			Pollen
	8	120-125	IIb		Pollen
T-207	2	91-95	IIa	Sandy clay sediment containing organics and freshwater snails (Stratum IIa) – likely former marsh/wetland.	Pollen
	6	107-111			Pollen
	11	127-131			Pollen
Submission 2:					
T-041	1	46-64	II	Alluvial silty clay loam (Ewa series: EmA) with charcoal flecking. Historically near taro fields and a rice plantation.	Pollen
T-067	1	152-154	II	Silty clay wetland sediments in stream floodplain– possibly taro and/or rice fields.	Pollen
	2	157-160	II		Pollen

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TABLE 1 (Continued)

Trench	Column Sample No.	Depth (cmbs)	Stratum	Description/ Provenience	Analysis
T-067 Cont.	3	167-169	II	Silty clay wetland sediments in stream floodplain– possibly taro and/or rice fields.	Pollen
T-161	1	130-165	IIa	Silty clay wetland sediments with organic matting at upper boundary– possible agricultural function.	Pollen
	2	165-140	IIa		Pollen
	3	140-145	IIa/IIb interface		Pollen
Submission 3:					
T-014	1	180-207	II	Alluvial silty clay loam with abundant organics and water-rounded gravel– historic maps show the area as within a land commission award and was likely used for taro and possibly rice cultivation.	Pollen
T-092	1	173-183	II	Marine clay within the historic Kuwili Fishpond (now covered by fill deposits).	Pollen
T-093	1	182-229	IIa	Silty clay wetland sediments within the historic Kuwili Fishpond (now covered by fill deposits). Contains organics and wetland snails.	Pollen
	2	250-274	IIb		Pollen
T-122	1	165-170	II	Wetland sediments containing potential agricultural evidence. Historic maps indicate a pond in this location.	Pollen
T-181	1	120-130	II	Sandy clay wetland sediment containing peat layers and organics. Historic maps indicate the trench is located within the Kolowalu Fishpond.	Pollen
T-184	1	139-147	II	Sandy clay wetland sediment containing freshwater/brackish snails. Historic maps indicate the trench is located within the Kolowalu Fishpond.	Pollen

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TABLE 2
PROVENIENCE DATA FOR SAMPLES FROM
HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT, AIRPORT SECTION

Trench	Column Sample No.	Depth (cmbs)	Stratum	Description/ Provenience	Analysis
T-006	1	162-175	II	Cobbly/stony silty clay loam. Historically near Waiolowai Stream.	Pollen
T-018	1	240	II	Clay overlying volcanic tuff– possibly Makalapa clay series.	Pollen
T-022	1	150-170	II	Silty clay loam– possibly Mamala soil series. Charcoal or black organic stains visible.	Pollen
	2	~200	II	Silty clay loam– possibly Mamala soil series.	Pollen
T-033	1	128-139	II	Silty clay loam with charcoal flecking.	Pollen

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TABLE 3
POLLEN TYPES OBSERVED IN SAMPLES FROM
THE HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT

Scientific Name	Common Name	Nat	Pol	End	Ind
TREES:					
Acacia	*Koa, kolu, koai'a*	x		x	
Alectryon	*Mahoe, 'ala'alahua*			x	
Anacardiaceae	Mango family	x		x	
Antidesma	*Hame, ha'a, ha'amaile, hamehame, mehame, mehamehame, bignay*			x	
Artocarpus	Breadfruit		x		
Bobea sandwicensis-type	'*Ahakea*, Hawai'i dogweed			x	
Cheirodendron	*'Olapa, lapalapa*			x	
Cocos nucifera	Coconut, *Niu, alolani*		x		
Colubrina	*'Anapanapa, kauila 'anapanapa*				x
Cordyline	*Ti*		x		
Ilex	*Kawa'u, 'aiea*, holly, English or European holly, yerba mate, Paraguay tea	x			x
Morinda trimera	*Noni kauhiwi*			x	
Myrsine	*Kōlea, 'Ōliko, Kōlea lau nui, Kōlea lau li'i*			x	
Myrtaceae	Myrtle family	x	x	x	x
Nothocestrum	*'Aiea, halena*			x	
Pandanus tectorius	*Hala, pū hala*				x
Pelea clusiifolia	*Kukaemoa, kolokolo mokihana*			x	
Pisonia	*Pāpala kēpau, pāpala*			x	x
Pittosporum	*Ho'awa, ha'awa*	x		x	
Pritchardia	*Loulu hiwa*, loulu palm			x	
Rhamnaceae	Buckthorn family	x		x	x
Straussia	*Kopiko kea*				x
Zanthoxylum	*A'e, manele, hea'e, kawa'u, kawa'u kua kuku kapa*, prickly ash			x	
SHRUBS:					
Broussaisia arguta	*Kanawao, pū 'ahanui*			x	

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TABLE 3 (Continued)

Scientific Name	Common Name	Nat	Pol	End	Ind
Charpentiera	*Papala*			x	
Chenopodium	*'Aheahea, 'ahea, 'ahewahewa, alaweo, alaweo huna, 'aweoweo, kaha'iha'i*, goosefoot, pigweed, lamb's quarters, Mexican tea, worm seed	x		x	
Cheno-am	*Achyranthes, Chenopodium oahuense, Amaranthus, Charpentiera*, etc.	x		x	
Cressa	Cressa				x
Dodonaea	Hopbush				x
Euphorbia (shrub or herb)	*Kaliko*, spurge, Mexican fireplant (wild poinsettia)	x		x	
Fabaceae	Legume or pea family	x	x	x	x
Senna gaudichaudii	*Kolomona, heuhiuhi, kalamona, uhiuhi*	x			x
Sesbania	*'Ohai*, Egyptian rattlepod	x		x	
Heliotropium	*Hinahina, hinahina ku kahakai, kipukai, lau po'opo'ohina, nena*, seaside heliotrope	x			x
Hibiscus	*Aloalo, hau, koki'o ke 'oke'o*, (*hau hele, koki'o kea, pamakani*), *ma'o hau hele, kaiohala*, (*akiahala, hau hele wai*), *koki'o* (*mākū*), large-leaved hau, cotton or confederate rose (*aloalo waikāhuli, waikāhuli*)	x		x	x
Kadua	*Au, pilo, 'Awiwi, kio'ele*, etc.	x		x	
Labordia	*Kamakahala*			x	
Malva	Mallow	x			
Plumbago	*Ilie'e, hilie'e*				x
Scaevola	*Naupaka*			x	x
Sida	*'Ilima*, prickly sida	x			x
Solanaceae	Nightshade family	x	x?	x	x
Vitex	*Kolokolo kahakai, hinahina kolo, mānawanawa, māwanawana, pōhinahina, pōlinalina*, beach vitex				x
Waltheria	*'Uhaloa* (*'ala'ala pū loa*)				x?

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TABLE 3 (Continued)

Scientific Name	Common Name	Nat	Pol	End	Ind
HERBS:					
Low-spine Asteraceae	Sunflower family; Includes ragweed and others	x		x	x
High-Spine Asteraceae	Sunflower family; Includes *Bidens*	x		x	x
Liguliflorae	Sunflower family, chicory tribe	x			
Boerhavia	*Alena, anena, nena*	x			x
Bonamia menziesii (Perispermum)	None (Vine in dry to mesic forest)			x	
Brassicaceae	Mustard family	x			
Lepidium	*'Anaunau, 'anounou, kunana*	x		x	x
Cleome	*Honohina, 'ili'ohu, honohino*, spider plant, spider flower, spider wisp,	x			x?
Commelina	*Honohono*	x			
Cressa truxillensis	Cressa				x
Plantago	*Laukahi kauhiwi*, plantain	x		x	
Polygonum sp.	Knotweed/smartweed	x			
Polygonum glabrum	*Kāmole*	x?			
Sicyos	*'Anunu*			x	
Stenogyne	*Pua'ainaka, Ma'ohi'ohi, Mohini*			x	
Tribulus	*Nohu, nohunohu*, goat head	x			x
GRASSES, etc.:					
Cyperaceae	Sedge family	x		x	x
Poaceae	Grass family	x		x	x
Typha	Cattail	x			
CULTIGENS:					
Colocasia	Taro, *kalo*		x		
Gossypium tomentosum	*Ma'o, huluhulu*, native cotton			x	
Oryza	Rice	x			
Saccharum	Sugar cane	x			
Vigna	*Mohihihi, nanea*, beach pea			x	x

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TABLE 3 (Continued)

Scientific Name	Common Name	Nat	Pol	End	Ind
ALIENS:					
Casuarina	Australian pine (*Paina*, ironwood)	x			
Leucaena	*Kao-haole* (*'ekoa*, *lilikoa*)	x			
Prosopis	*Kiawe*, mesquite	x			
Indeterminate	Too badly deteriorated to identify				
Unidentified striate					
SPORES:					
Dicksoniaceae	Tree fern family			x	x
Lycopodium cernuum	Club moss (*Wawae'iole*)			x	
Monolete smooth or bumpy	Fern				
Trilete smooth or spiny	Fern				
OTHER:					
Tetraploa	Fungal spore				
Starch angular	Grass seed-type starch				
Foraminifera	Forams				
Botryococcus	Algal body				
Concentricyste	Algal body				
Spirogyra	Algae				
Scolecodont	Polychaet worm jaw				
Microscopic charcoal	Microscopic charcoal				
Charred Asteraceae fragments	Charred pieces of a member of the sunflower family				
Charred Poaceae fragments	Charred pieces of grass				

Plant names and information derived from (Wagner et al. 1990)
Fern (spore) names derived from (Selling 1946)

Nat = Naturalized
Pol = Polynesian introduction
End = Endemic
Ind = Indigenous

Pollen identifications to species were made based on the fact that only 1 species is reported by (Wagner, et al. 1990). Species identification was not made based on morphologic characteristics observed under the microscope.

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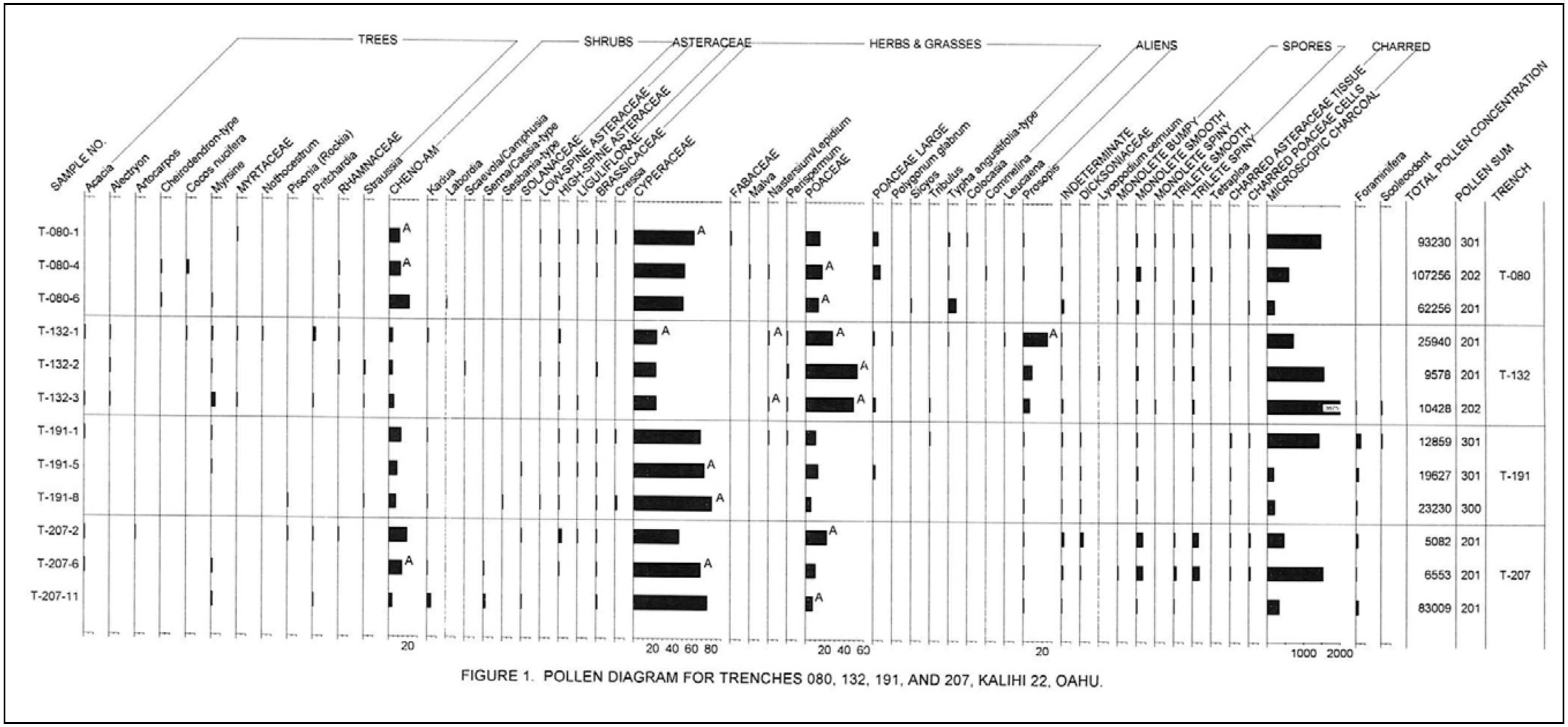

FIGURE 1. POLLEN DIAGRAM FOR SUBMISSION 2 SAMPLES, CITY CENTER SECTION

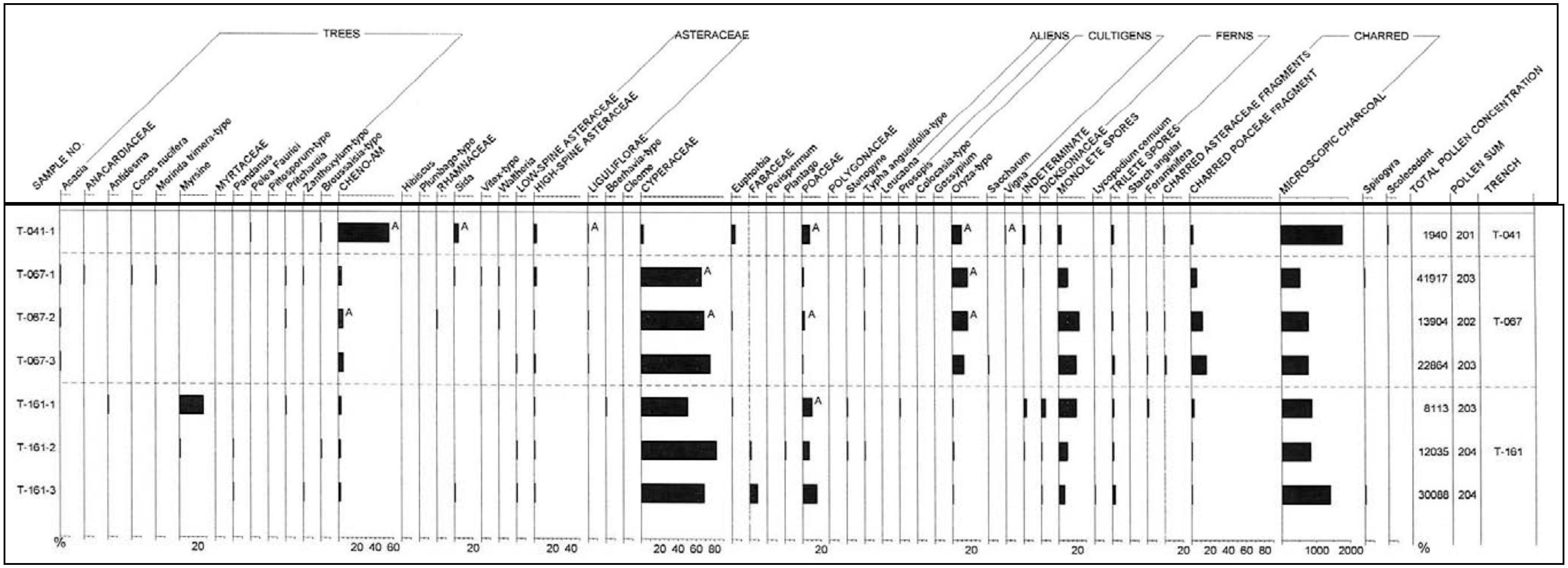

FIGURE 2. POLLEN DIAGRAM FOR SUBMISSION 2 SAMPLES, CITY CENTER SECTION

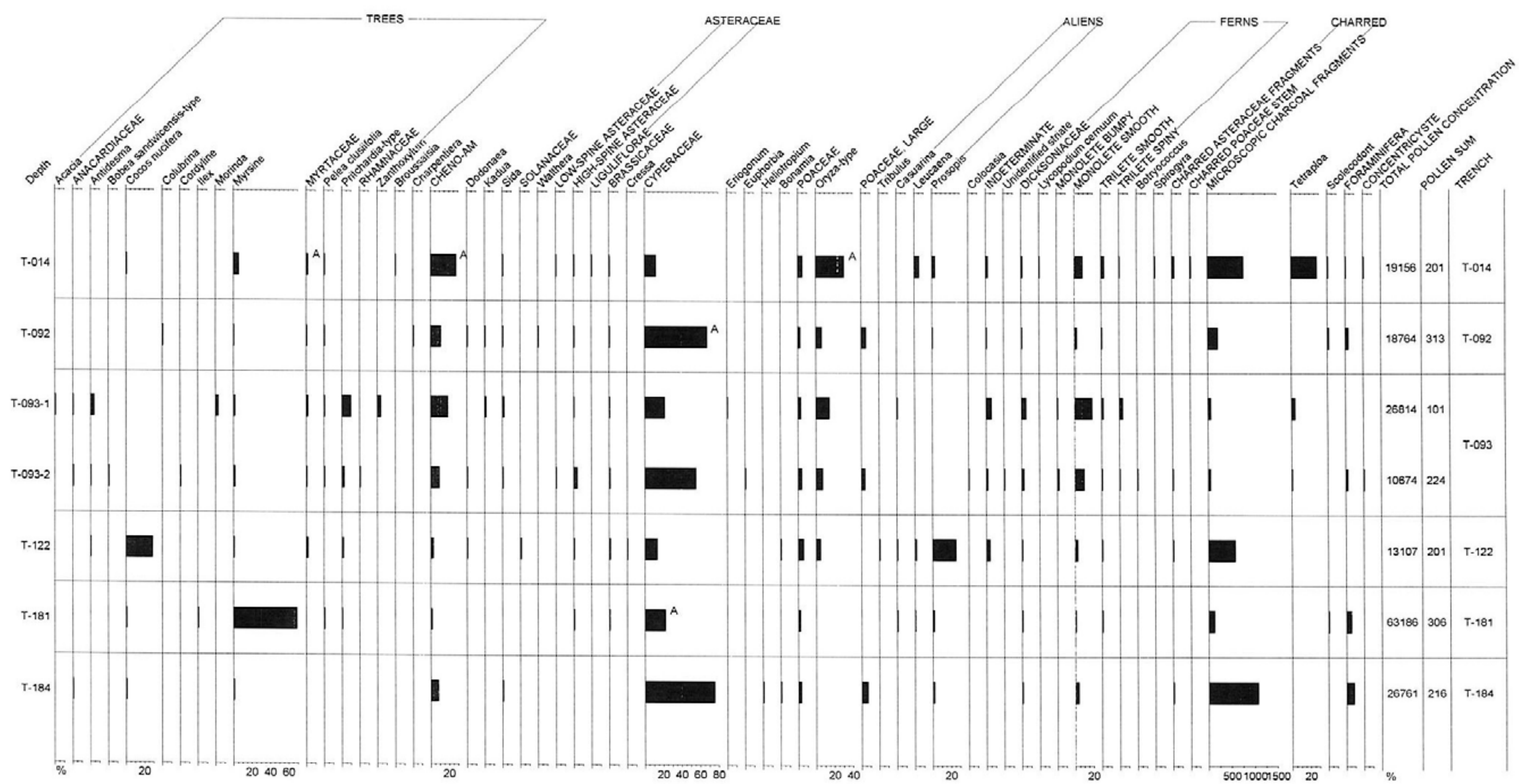

FIGURE 3. POLLEN DIAGRAM FOR SUBMISSION 3 SAMPLES FROM CITY CENTER.

FIGURE 3. POLLEN DIAGRAM FOR SUBMISSION 2 SAMPLES, CITY CENTER SECTION

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